XXXVI.—*On Fatty and Amyloid Hysterophymata.*

By H. Karsten.

During the last decennia the form of those small organized corpuscles which occur in the diseased, dying, and dead tissues of organisms, and in fermenting and putrefying fluids, &c., cellular vegetations which I have named Hysterophymata (see 'Faulniss und Ansteckung'), as they only originate from already existing specific organisms as morbid formations, has been frequently the subject of observation; but their chemical constitution has hitherto scarcely been referred to.

That these ferment-corpuscles are pathological cells, but not specific organisms, that their form is dependent on the prevalent conditions of nutrition, and that therefore their different developmental forms, produced by these conditions, do not make their appearance in a regular cycle as in the development of organic species, has been already proved by me partly in this Journal (1874, vol. xiii. p. 161 *et seqq.*), and partly in other places there referred to.

In like manner, the sequence of chemical actions during the process of the development of these cell-vegetations is not definitely limited and regular in its course like that which constantly repeats itself in endless cycles and with but slight deviations during the development of the seed or the egg, but is dependent upon the passing chemical constitution of the nutritive fluid and the physical conditions.

That these pathological cells, which accompany the morbid processes of organic creatures, which often produce these, and may even, under certain circumstances, cause the death of organisms, produce from themselves by their assimilation-processes many different products, colouring and odoriferous matters, organic acids, &c., which are usually regarded as products of organic decomposition, has been explained by me in my 'Chemismus der Pflanzenzelle' and elsewhere. On account of the extreme smallness of these bodies, however, it has hitherto been very difficult to convince one's self of the production of these matters by their assimilating membrane. The physical and chemical properties of fat and amyloid, which matters, as I have ascertained by experiment and observation, are also produced by the assimilating activity of these hysterophymata, considerably facilitate our acquisition of this conviction; for just as the fats which are developed by the normal process of life of plants and animals owe their origin, according to my investigations *, to the assimilating membrane of the oil-, fat-, and wax-cells, erroneously in part regarded as drops, so is the necrobiotic product adipocire the production of the metamorphosis of assimilating membranes of the hysterophymata which generate this matter.

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* H. Karsten, 'Gesammelte Beiträge' &c. pp. 107, 278, 313, &c.: C. Harz, "Olivenöl," Bericht der Wiener Akad. 1870.

I have observed the production of a kind of adipocire in intercostal and lumbar muscles from the pig and rabbit, which were in an atmosphere rich in carbonate of ammonia.

The production of the fat in the temperature of a room was a very tedious affair; it scarcely commenced, in the experiments made by me, under a year. The pieces of meat were hung freely in well-stopped vessels containing a little carbonate of ammonia, which was renewed from time to time. The fat thus produced was white, soft, and greasy, and chiefly soluble in ether. Perhaps an air richer in carbonic acid, or a lower temperature, would give rise to the formation of a harder fat more like adipocire.

During the slow alteration of the tissues composing the muscles there were first of all developed (in four weeks) from the *Micrococci*, which soon made their appearance, cylindrical, many-jointed *Vibriones* (*Bacteria*) in tissue (cells and fibres) of the flesh; afterwards the terminal joint-cell of these became spherically inflated ('Chemismus der Pflanzenzelle,' p. 25, fig. v. 4 *d*), and, indeed, first in those contained in the vessels, subsequently in those in the muscle*; then it became separated from the other joint-cells, and developed into filiform and chain-like structures (*Leptothrix*, *Mycothrix*, *Coccus*-chains); finally these also broke up into thin somewhat enlarged joint-cells, which I saw dissolve away when brought into contact with ether upon the object-bearer. In about two years the pieces of muscle were converted into a uniform fatty mass, which, when pressed under the glass cover, emitted oleaginous drops which enveloped numerous vesicles.

The process is different in the development of the amyloid, inasmuch as this does not originate from the membrane of the mother cell, *i. e.* the membrane of the *Coccus* (= *Vibrio*) itself, but from that of its daughter cells. The youngest developmental stage of the hysterophyma-germs from the normal cell-embryos of the fluid cell-contents of plants and animals contains albumen like the cell-embryos. In different *Vibriones* &c. formed during the butyric fermentation from fleshy fruits, roots, &c. (cucumbers, potatoes, beetroot, turnip, carrots, Jerusalem artichokes, dahlias), their contents-cells at about 25°–35° C. (= 77° – 95° F.), and with suitable nutritive materials (I found a solution of one half per cent. of phosphate of soda and ammonia particularly favourable), acquired first of all the chemical constitution of the amyloid found in the animal body, and soon after that of lichen-starch, when the development had proceeded further. Contact with solution of iodine produces first a yellow, then a yellowish brown, afterwards a reddish violet, and then a blue coloration. Simultaneous treatment with Millon's nitrate-of-mercury solution shows likewise that the amount of albumen continually decreases. If the fluid in which the organisms rendered blue by iodine are suspended be allowed to evaporate, or warmed for some time until the iodine is evaporated, the amyloid loses its blue colour, which reappears not on cooling, but by fresh contact with solution of iodine. When boiled the amyloid hysterophymata furnish neither jelly nor paste, by which they are distinguished from vegetable amyloid and starch; chloride of calcium does not cause them to swell; alcohol leaves them unaltered.

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* I have seen a state in which the muscular fibres were completely filled with cylindrical, and the vessels with nail-like *Vibriones*.

The form of these sometimes comparatively large amyloid-forming cell-vegetations shows almost all the variations which the hysterophymata in general put on (except *Sarcina* and *Spirillium*). We find simple cells (*Cocci*) and chains of such cells, as well as *Vibriones* (called *Bacteria* in the resting state) and their chain-like series, which frequently seem to pass into *Leptothrix*-filaments, and, when they are somewhat twisted and acquire a screw-like movement, have some resemblance to *Spirillia*. Very frequently in this stage of development the *Vibriones*, by one or both the terminal cells being spherically inflated, become nail-like (*claviformis*) or handle-like (*ansæformis*); moreover the originally cylindrical *Vibriones* become club-shaped (*clavatus*) by the joint-cells towards one end being gradually inflated; or while one terminal cell swells into an oval form, the other joint-cells remain without solid contents and coalesce, and the *Vibrio* becomes tadpole-like (*gyriniformis*). All these last-mentioned forms also form chains[*].

The complete development from the first excessively minute germ-cells produced during the dying-off of the mother cell, to the perfect amyloid hysterophymata (some of which grow almost to the size of milk-yeast, see 'Chemismus der Pflanzenzelle,' 1869, p. 13, fig. II. 6, and III. 2), takes place under the most favourable conditions, as above indicated, in from twenty to twenty-four hours. By observations repeated every two hours during this time we may very easily follow the whole course of development step by step, and ascertain by effecting a contraction of the secondary cells by the employment of diosmotic agents, or by sudden considerable alteration of temperature, &c., that in fact the production and development of these hysterophymata takes place within these cells. In from eighteen to twenty hours the first indications of bluing by iodine usually occur; we find individual joints of the *Vibriones* somewhat inflated, the terminal joints most frequently, and these also separated and coloured blue by iodine in the midst of the great mass of yellow *Dicocci*, *Vibriones*, &c. which were developed somewhat later and more slowly.

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[*] That all these form-variations of necrobiotic cells have been regarded by systematists and doctors, to whom their true nature was unknown, as new genera of peculiar organisms, is a striking proof of the necessity of a knowledge of developmental history in the investigation of organic nature (see Nüesch, 'Necrobiose,' 1875, Schaffhausen).

The development of the hysterophymata takes place free in the nutritive fluid, which always contains the contents which have flowed out of the torn or cut cells, and also in the cut cells themselves, much more rapidly than within the closed cells; and we may see several or all the joints of a *Vibrio* simultaneously develop daughter cells, inflated in various forms, and become coloured blue by iodine, while the germs enclosed in the cells have scarcely commenced their evolution. But all the cells of the tissue of a beetroot &c. do not behave in the same manner; nor do all simultaneously develop the same forms in their interior, but earlier or later according to the more or less albuminous nature of the contents. Hence the elongated cambium-cells in the neighbourhood of the vascular bundles are earlier than the cells of the parenchyma; whilst of the latter again some are earlier than the others, according to the constitution of their continually changing contents, which is dependent upon their age and their chemical stage of development.

The cells nearest the surface are also naturally much earlier and more intensely penetrated by the nutritive fluid and excited to the new formation above described than those situated more in the centre of the organ, which frequently develop none of the large vibrioniform cell-structures, becoming blue with iodine when some time has elapsed since the commencement of the process. In these cells *Vibriones* certainly are developed, but only albuminous ones, which are coloured yellow by iodine and reddish by Millon's salt.

It would appear that for the evolution of the amyloid hysterophymata an organic compound soluble in water is necessary, which diffuses itself outwards from the cells situated in the interior of the tissue, where the latter is permeated by an insufficiently concentrated solution of nutritive material,—and that, on the other hand, the salts of the nutritive material are held back by the superficial layers of cells in the same way that the humus covering prevents the nutritive salts of plants from sinking into deeper layers of the soil.

For all these reasons, there is in the portions of tissue serving for experiment, and in the nutritive fluid with which these are surrounded, a great multiplicity of developmental stages and forms of the cells originating and developing during the close of the normal process of vegetation and the commencement of the morbid processes of nutrition and growth.

Moreover the above-described variations of amyloid hysterophymata under certain circumstances furnish the most beautiful proof that they are all only developmental forms of Müller's "*Vibrio*," as I have already shown in my memoirs on the "Chemismus der Pflanzenzelle," 1869, and on "Fäulniss und Ansteckung," 1872. These comparatively large bodies, which show nothing of vibratile cilia or other organs of motion (unless we are to reckon as such the still uninflated joint-cells), are seen sometimes moving so briskly in the most different directions in a confused throng, sometimes with the thicker, sometimes with the thinner end forward, the *Vibrio*-twins and chains like automatic snakes, the *Leptothrix*-filaments sometimes, when they are curved, passing one another in the form of a screw like *Spirillia*, swimming with and against the current, and apparently performing voluntary movements, that no one not familiar with the objects can be blamed for regarding these organisms as animals. And yet they are only pathological cell-forms! as their developmental history teaches us. By the addition of a trace of solution of iodine the movement is immediately stopped; the bodies, which are then coloured blue, lie motionless before the observer.

The cause of this movement, which, under favourable conditions, is extraordinarily brisk, appears to be the evolution of the gases produced from the cell-membrane during the butyric fermentation (about $\frac{2}{3}$ carbonic acid and $\frac{1}{3}$ hydrogen and carburetted hydrogen gases). As long ago as 1869 I called attention to this circumstance (Chemismus &c. p. 32), and said that many *Vibriones* do not lose their mobility even at the boiling-point of their nutritive fluid, as I observed at that time after the conclusion of the distillation of a fluid of this kind containing *Vibriones*, the fermentation of which continued uninterruptedly after the distillation, although care was taken that no air could penetrate into the vessel which contained the fermenting fluid.

These mobile amyloid hysterophymata, which are produced even when pure water is employed, are obtained in greatest number when a piece of beetroot is digested in a closed vessel for twenty-four hours at a temperature of 35°–40° C. (=95°–104° F.) in a solution of one half per cent. of phosphate of soda and ammonia. At a lower temperature it takes longer under otherwise similar conditions before this phenomenon is manifested. Thus it requires four days at about 15° C. (=59° F.) and three weeks at 6° C. (=42°·8 F.). At 0°–5° C. (=32°–41° F.) we see the *Vibriones* &c., which then move less briskly and not so generally, grow in from four to six weeks from the albuminous simple germ-cells into the cylindrico-filiform and the various other above-mentioned forms of amyloid hysterophymata.

As has already been stated, the germs diffused and freely floating in the nutritive fluid are always developed earlier than those enclosed in the cells, as also usually are those contained in the intercellular spaces (see 'Chemismus' &c. p. 35), just as in general the development of the germs between the superimposed membranes of a tissue-cell system advances from without inwards, and this not only in vegetable but also in animal cells, *e. g.* in those of cartilage.

During this development of amyloid hysterophymata the nutritive fluid very soon becomes acid by the formation of lactic and butyric acids.

Under these conditions, at the above temperature there commences a retrogression of the amyloid bodies; the younger cell-vegetations originating in their joint-cells absorb the amyloid without forming fresh, and become developed into small *Dicocci* and *Bacteria*, which are rendered yellow by iodine.

The production of the organic acids promotes the development of the *Vibrio* joint-cells into yeast; an addition of sugar to the fluid containing amyloid hysterophymata, even when it is boiled for hours and with the greatest care, hastens this development of yeast; so also an addition of dilute phosphoric acid, in which even fresh vegetable tissue develops yeast instead of *Vibriones*.

Schaffhausen, February 1876.

XXXVII.—*On the Actinozoan Nature of* Millepora alcicornis, *Dana and Linn.* (*pars*). By R. G. NELSON, Major-General R.E., and P. MARTIN DUNCAN, F.R.S. &c.

EVERY one who has examined the hard parts of a Millepore critically is impressed with the existence of calices, limited beneath by tabulæ, and separated by more or less spongy-looking cœnenchyma consisting of reticulate and excessively